

CALO

Cognitive Assistant that Learns and Organizes

Enduring Personal Cognitive Assistant: DARPA's perspective

- ◆ Will have and use *knowledge* of the domain, task
- ◆ *Cognitive awareness*: will have experiences; perceptual input integrates with knowledge, model-based filtering
- ◆ Can *imagine* possible futures
- ◆ Can *decide* what to do and act in real time (prioritize)
- ◆ *Learns*, including by observing partner
- ◆ Can be *advised* and *guided*, and can *explain*
- ◆ Must know how to *cooperate* (be a team player)
- ◆ Uses *multi-modal*, broad-spectrum interaction
- ◆ Should be available everywhere - *omnipresent*
- ◆ Must be *trustworthy*
- ◆ Must *learn continuously*
- ◆ Must be able to *survive*, operate through problems

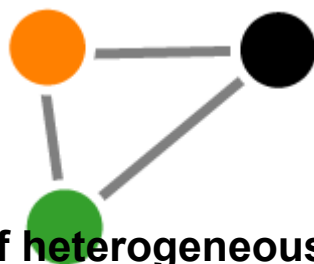
CALO Vision

- ✓ **Frees you to be more**
does what you need done, the way you want it done
- ✓ **Serves you better and more reliably over time**
- ✓ **Devoted to you, but plays well with others**
your CALO interacts with other CALOs and with external sensors
- ✓ **Necessary and unobtrusive as a watch – so valuable, you won't leave home without it**
embodied as a software environment that transcends workstations, PDA's, cell phones, ...



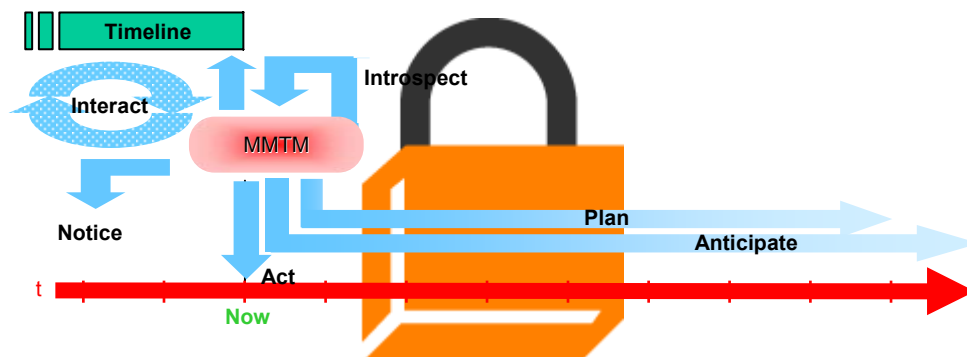
Technical Challenges

Enduring improvement through learning



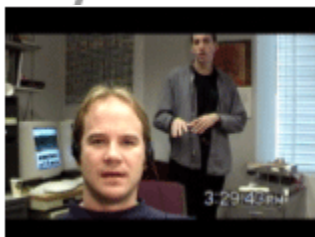
Integration of heterogeneous cognitive components

Robust mixed-initiative multitasking in a changing environment



Establishing and maintaining trust

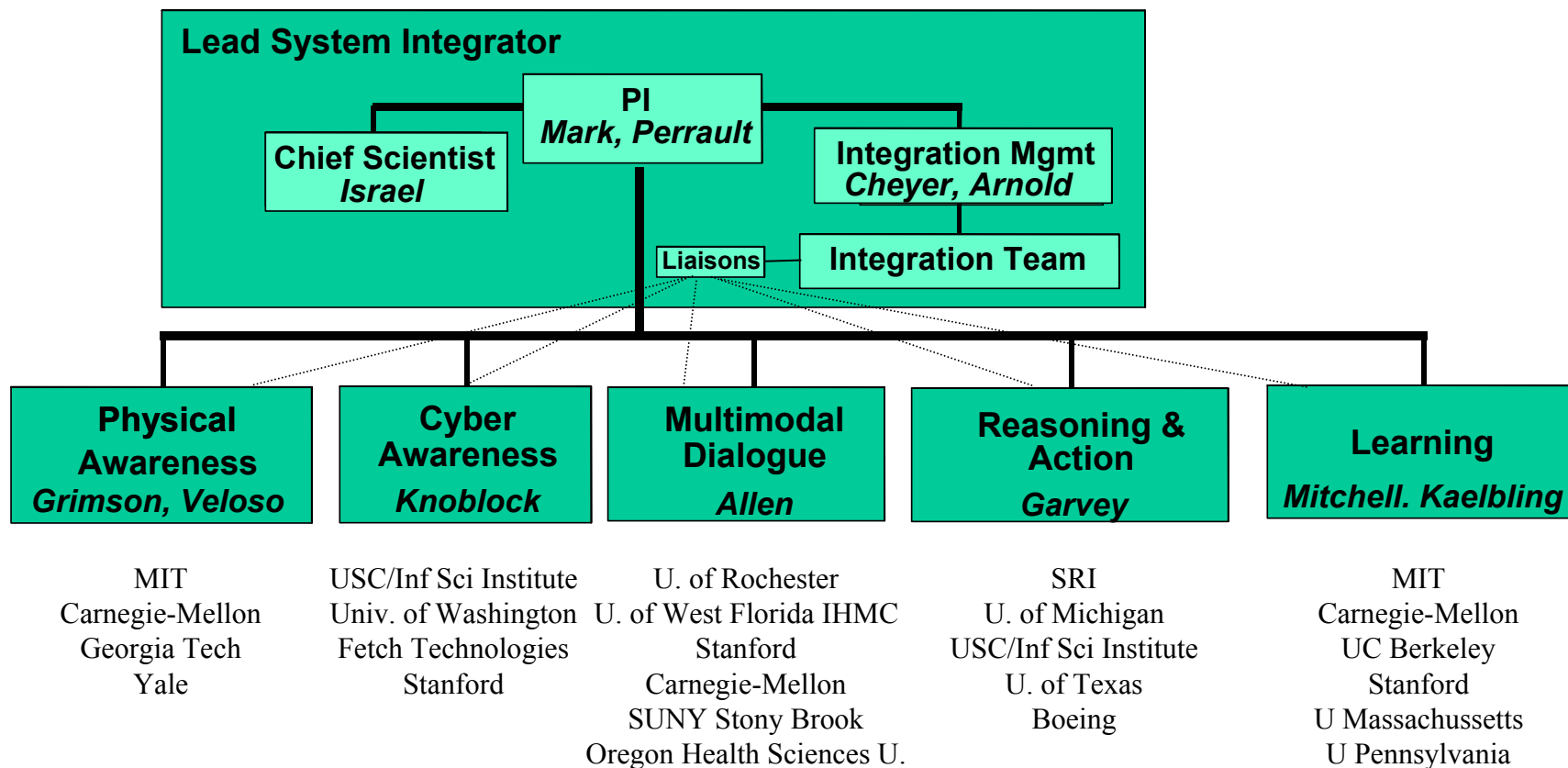
Knowing what's out there



Seamless use across platforms



CALO Team



◆ Year 1 Taskable/Observant

CALO carries out specified tasks, defined in terms of workflows (e.g., handling email) composed of primitive actions (receiving message, reading message, saving message in folder, etc.) CALO learns user preferences.

◆ Year 2 Advisable/Advising

CALO takes user advice about importance of tasks, how to achieve tasks, and how to recognize task-related events. Tasks are still user-initiated, but CALO notifies the user of conflicts among workflow activities. CALO defers to user priorities and preferences.

◆ Year 3 Collaborative

CALO works closely with the user to elaborate and define tasks and responses to events. CALO learns new ways of accomplishing workflow objectives, including incorporating new tasks (e.g., new functionalities provided by others) into its existing workflows.

◆ Year 4 Extroverted

CALO assumes greater responsibility in initiating and terminating workflows, and choosing among appropriate strategies for achieving user's goals. CALO actively seeks out new opportunities for meeting user goals and the information it needs fully to take advantage of those opportunities.

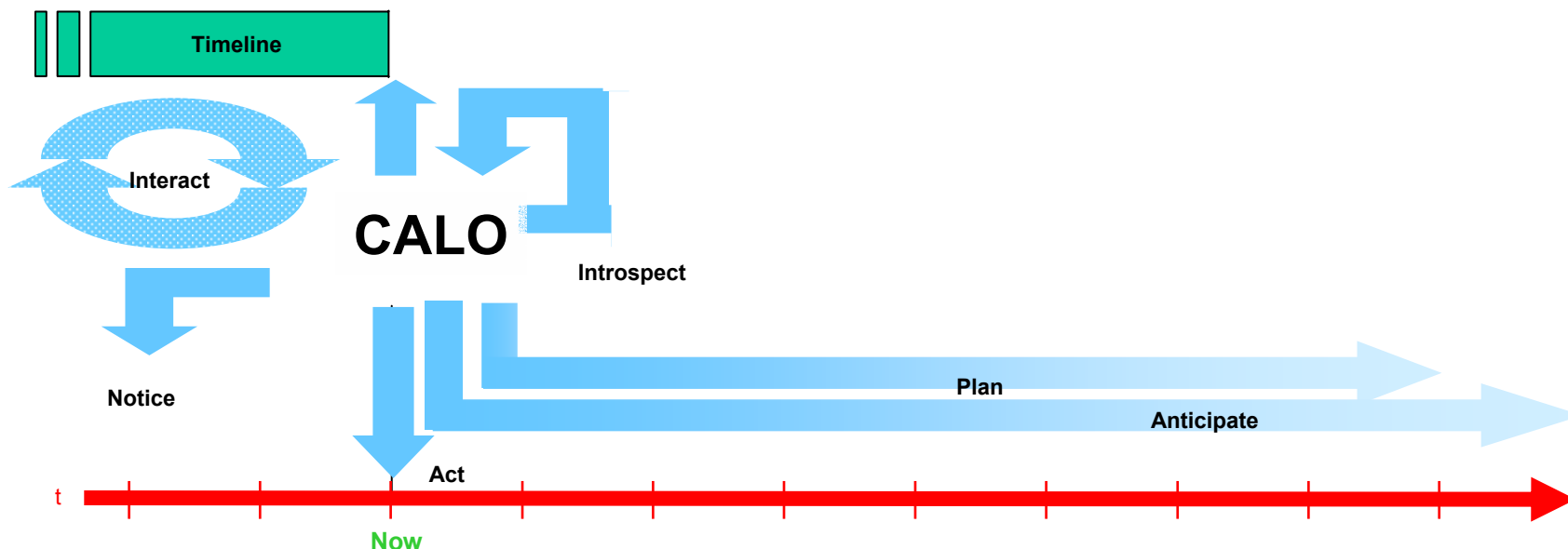
◆ Year 5 Empowered

CALO is trusted to act on behalf of the user in many circumstances. Much of this delegation is implicit. Interaction with the user is primarily in terms of high-level goals, decisions, and activities. CALO introspectively explains its decisions and actions.

Concept of Operation

CALO is always:

- Noticing things in the cyber and physical environments**
- Aggregating what it notices, thinks, and does in the Timeline**
- Executing, adding/deleting, suspending/resuming tasks**
- Planning to achieve some objective**
- Anticipating things it may be called upon to do or respond to**
- Interacting with or planning to interact with the user**
- Adapting its behavior in response to past experience, user guidance**



CALO Learning

Relational: Learn relationships among entities

Sequential: Learn the dynamic structure of ongoing activity of the user

Procedural: Learn to handle new tasks through planning

Inferential: Reason to learn new facts

Perceptual: Learn to associate images and sounds with other knowledge

Reflection

Observation

Interaction

Inference

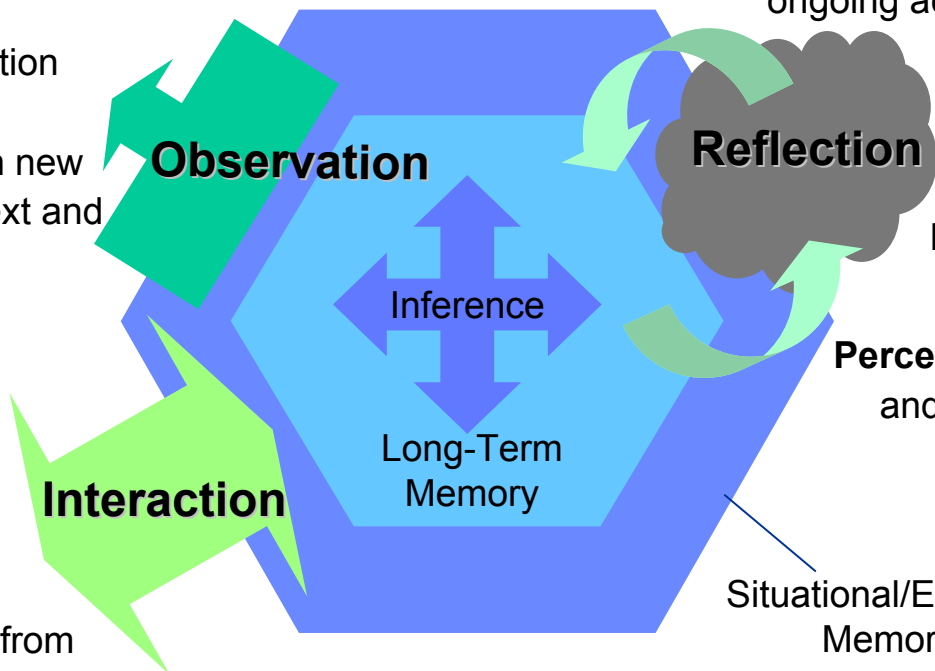
Long-Term
Memory

Situational/Episodic
Memory

Category: Learn relevant groupings for observed information

Language: Learn new information from text and utterances

Advice: Learn from the user



CALO Learning

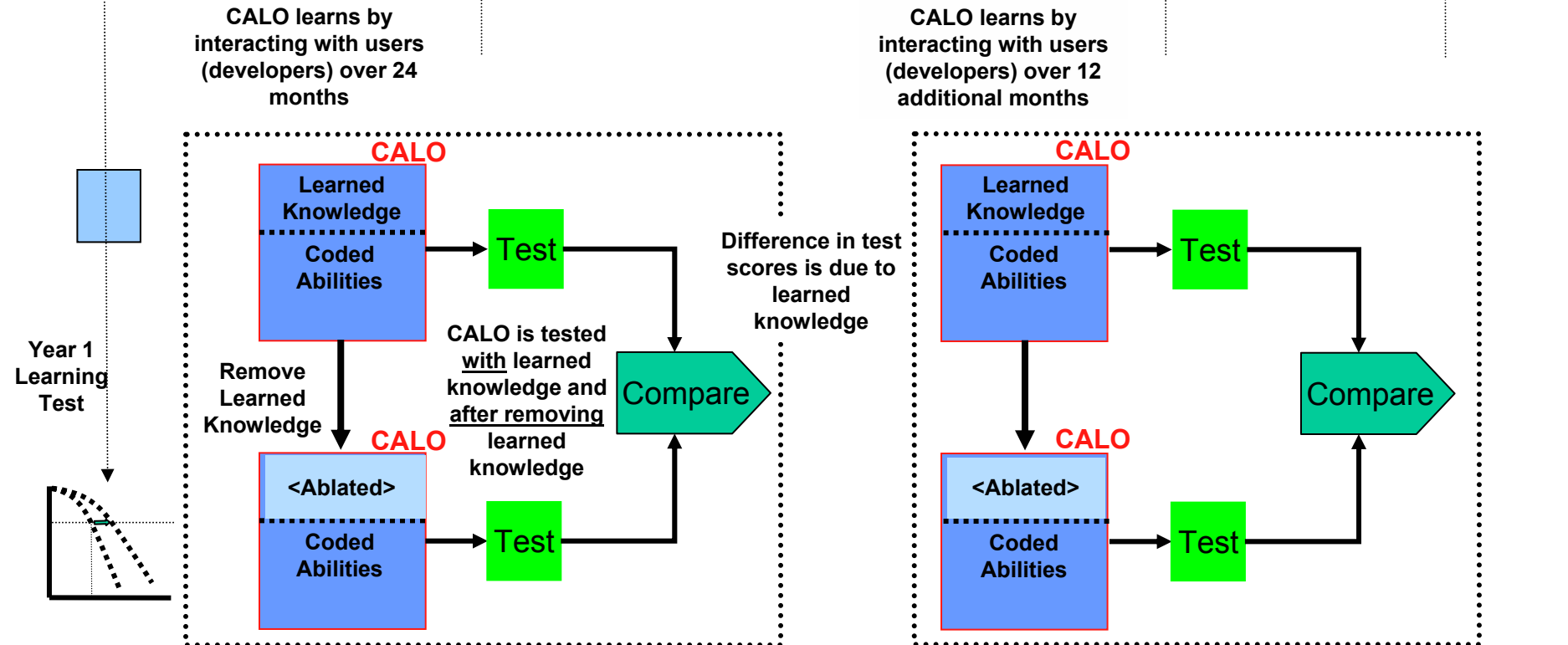
CALO learns in many ways

- ◆ **Inherent**
 - Vision and speech recognition use learning in their core algorithms
- ◆ **Contextual**
 - **Language:** Learn to classify documents and to extract their factual content
 - **Perceptual:** Learn to recognize (attach names to) people and places, primed by knowledge of relations
 - **Relational:** Learn relationships between entities (meetings, topics, people, documents, mail messages, meeting rooms) in the world
 - **Sequential:** Learn the dynamic structure of ongoing activity of the user: meetings, travel, commute
 - **Heterogeneous data sources:** Learning from partially labeled and heterogeneous data; transfer
- ◆ **Advice-Based**
 - Learn from coaching by the user

Measure CALO performance improvement due to learning every 12 months

Month 12 24 36 60

Collect Timeline Data



- **CALO at 36 months incorporates new coded abilities and additional knowledge learned over the preceding 12 months**
- **Test is identical**
- **Entire process is repeated every 12 months**

CALO Exam

- ◆ **Patterned after standardized achievement tests (e.g., the Advanced Placement Exams)**
 - Each problem consists of a brief scenario followed by questions and exercises based on that scenario
 - All questions and exercises have objectively determined “best answers”
- ◆ **Exam is administered by an external examiner (not a member of the development team)**
- ◆ **Problems are shown on the following slides**

Project Setup Problem

Scenario A: Set up a high-priority project to deliver a program plan two weeks from today. The participants are Bob (designer), Ted (programmer), Carol (project leader) and Alice (boss). Their schedules are available to you. Set up meetings to discuss strategy, budget, specific objectives and schedule. Not everyone needs to attend all the meetings.

- A.1** Carol is now unable to attend the budget meeting as scheduled. What does CALO recommend?
- A.2** Ted is now unable to attend the budget meeting as scheduled. What does CALO recommend?
- A.3** Bob is now unable to attend the strategy meeting as scheduled. What does CALO recommend?
- A.4** Alice needs to travel to Boston during the first week of the project. How does CALO handle this?
- A.5** 15 minutes before the weekly budget meeting, Carol is still at home. What does CALO do?
- A.6** The project budget overruns by 10%. What does CALO do?

Project Execution Problem

Scenario B: We're in a project meeting. We will be discussing technical progress and some budget issues. We absolutely have to pick one of the system architecture alternatives this time. This is Bob's first meeting as a member of the team; he's a software developer.

- B.1** Which architecture was picked?
- B.2** Who wrote on the board at 2 PM?
- B.3** Send Bob the critical-path slide we edited in the meeting.
- B.4** Who had questions about slide10?
- B.5** Was John upset about his action item?
- B.6** Is the project on budget?
- B.7** In anticipation of user needs, what files does CALO put on the user's desktop?
- B.8** Does CALO identify any action items for after the meeting?

Equipment Purchase Problem

Scenario C: I need to purchase a laptop computer with a clock speed of 1.5GHz, 500MB of RAM and a 200GB hard drive. I can spend up to \$1500. Find me an appropriate machine and get approval to purchase it (e.g., retrieve 2 bids from competing vendors, complete the online purchase requisition form, get authorizations from management). I need to place the order within 4 hours.

- C.1** Did CALO find a computer that met the requirements?
- C.2** Did CALO get two bids?
- C.3** Did CALO get two authorizations?
- C.4** Did CALO complete the requisition form?
- C.5** Did CALO meet the task deadline?